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CALDWELL'S

Slide Valve Calculator.

DIRECTIONS FOR USING.

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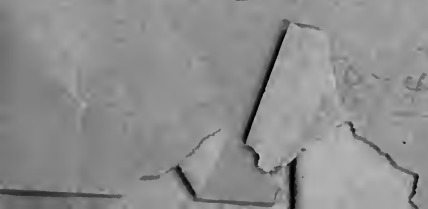

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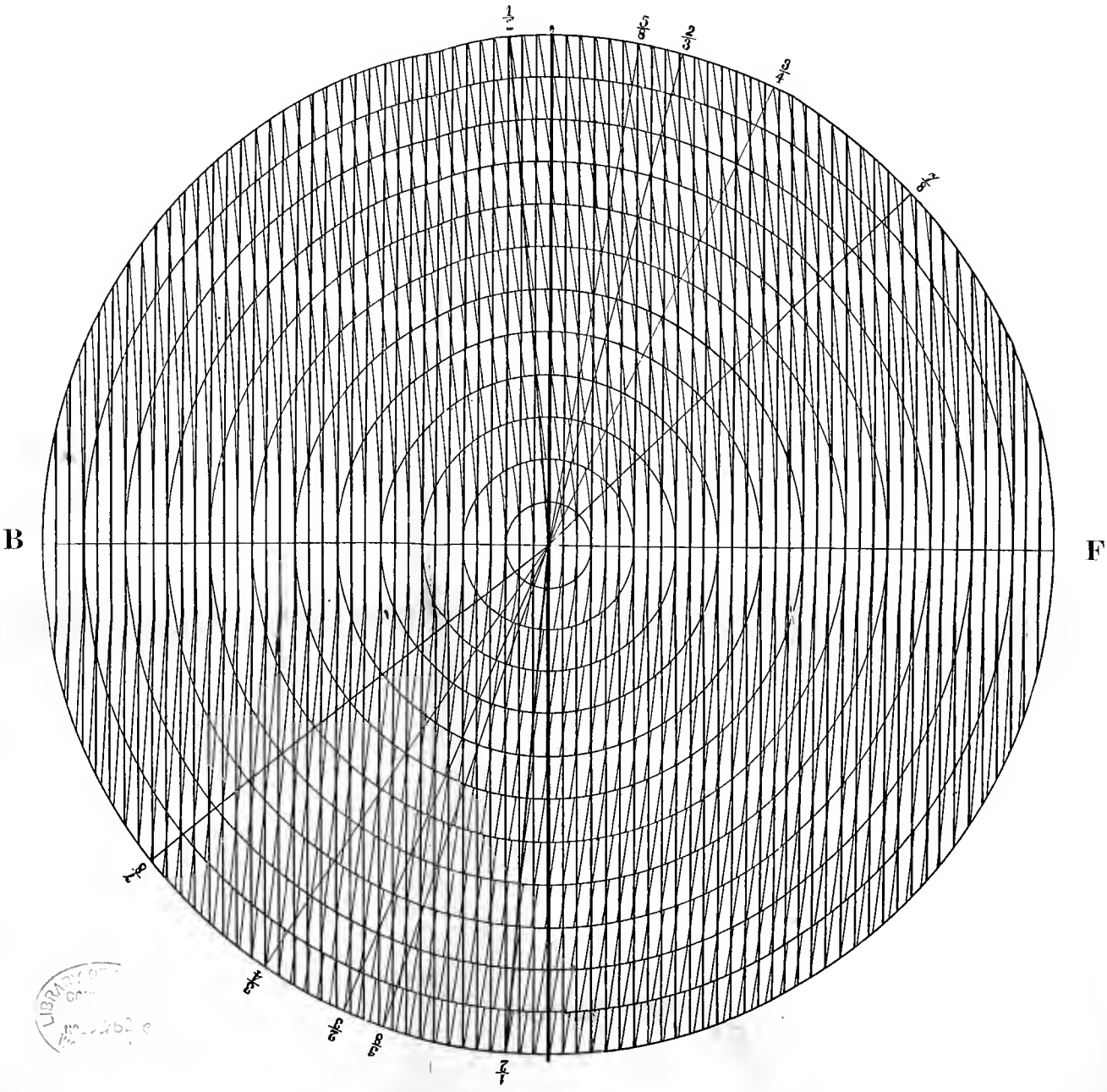

All Calculations relating to the action of the Slide Valve, no matter how intricate, can be solved in a few moments by the use of the Calculator The information it gives is read off at sight, and is at once intelligible and CORRECT.

By a short examination the following points can be ascertained by a person of common attainments, every point proving itself as the examination progresses.

1. The proper travel of Valve to produce certain results.
2. The proper Lap to Cut off at given part of stroke.
3. " " Exhaust " " "
4. " " Cushion " " "
5. " " Cut off equal on each side of Piston.
6. " " Exhaust " " " "
7. " " Cushion " " " "
8. The proper width of Exhaust port to prevent back pressure.
9. The proper Lead to give the Valve.
10. The proper amount of opening for admission of Steam.
11. The position of Eccentric on Shaft.
12. The relation of Valve to Piston at every part of the stroke.

These points ascertained at sight with Lead or without it.

DIRECTIONS FOR USING

CALDWELL'S

SLIDE VALVE CALCULATOR.

Cut paper Template, (See fig. 1,) the large circle representing the stroke of engine, eighth size, and the small circle the travel of the valve, full size. For an engine 24 in. stroke and 2 in. travel of valve, these circles would be respectively, 3 in. and 2 in.

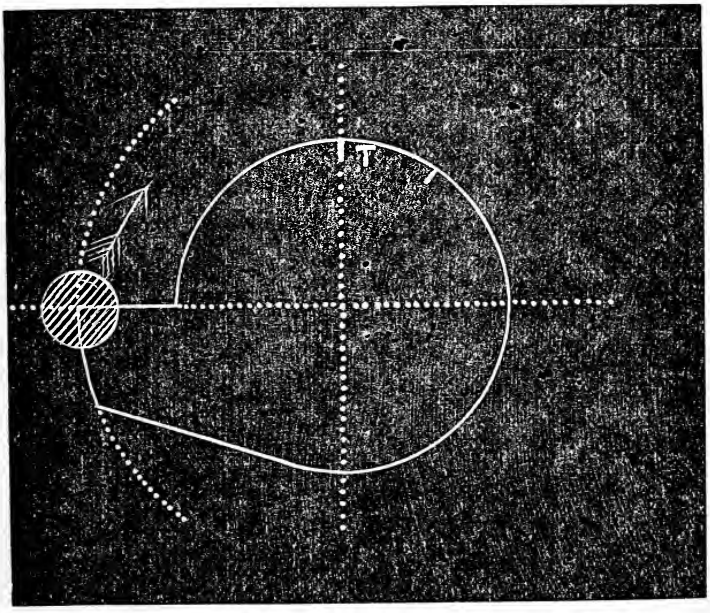

FIG. 1.

Place the Calculator before us so that the letters B. and F. will read from left to right. Place the Template on the Calculator, and bring their centres coincident, and drive a pin through both; turn Template till it takes position shown in Fig. 1. The small circle P., Fig. 1, denotes the Crank Pin, $\frac{1}{4}$ of it occuring on Template.

On Template at T, Fig. 1, coincident with thick line on Calculator, make small mark, now turn the Template round till the mark reaches the next verticle line. toward F, and the Valve has opened the Steam Port $\frac{1}{8}$ in.; another reached and it is opened $\frac{1}{4}$ in., and when the mark has got round to the line B. F. the port is open as much as it will open, and the CRANK PIN has made half stroke, but the exact position of Piston in Cylinder will be found by counting the number of curved lines from either end of "Stroke Circle," toward the Crank Pin.

Moving the Template further round, the mark returns; and when the next line is reached the port is $\frac{1}{8}$ in. closed, and when mark is again coincident with thick line, the port is closed.

It will be evident by this time the thick line has been the receiving edge of Steam Port, and the mark the receiving edge of valve; and since the valve had no lap, the Crank Pin is on the dead centre line B. F. Now, we must assume the thick line to be the EXHAUSTING OR INSIDE edge of Steam Port, and the mark the exhausting or inside edge of Valve. This being understood we proceed to turn Template round again, and when the first line on the B. side of thick line is reached, then the exhaust port is opened $\frac{1}{8}$ in., provided the valve has no inside lap, for if it had $\frac{1}{8}$ in. inside lap then the mark would just have reached the thick line or edge of port; this would be bad, as we see the Crank Pin is already started on its way back; but we shall say the Valve has NO inside lap and proceed; so the port is open $\frac{1}{8}$ in. and when the mark shall reach the line B. F., the exhaust will be open as much as this travel of valve will allow, and when at thick line again, is closed, and engine has made one revolution. The Crank Pin on the dead centre line, and mark at thick line, ready to leave it by the advance of the Crank Pin, and represent the action of taking steam as before. A Valve constructed thus would read:

Travel of Valve,	2 inches.
Cut off,	0 "
Exhausts from end of Stroke,	0 "
Expands,	0 "
Cushions,	0 "
Lap,	0 "
Steam Port opens,	1 "
Exhaust Port opens,	1 "
Lead,	0 "

This was the kind of Valve in use for some time after the steam engine was invented, and even at this late day tell tale diagrams, taken up to date, show that the good effects of Lap is either not appreciated, or understood by some builders yet.

It may not be amiss to say here, that the word Lap is often used when it would be more appropriate to say Cut off; for instance we hear of a Valve having so much Lap, instead of at what part of the stroke the Lap cuts off the steam; the first has no meaning, whereas the latter tells the economy aimed at, other things being equal.

But of more importance even than this is the action of the exhaust. The same diagrams show fearful waste of steam in this direction also; in fact there can be no other conclusion; after examining many diagrams and valves off engines by different builders, both east and west, than that there is wide spread ignorance on this subject. Some builders give the same outside and inside lap on all occasions, no matter what the size of the engine, or travel of the valve.

It ought to be understood that the result of inside lap is to exhaust too late and cushion too early; occasioning back pressure all the way, and making bad worse by shutting off what small passage there is, before the piston is near the end of the stroke, and compressing what steam there is left in the cylinder, that had not time to get away, into less volume, increasing its pressure above the pressure in the steam chest, till it forces the valve off its seat and

escapes into the steam chest among the live steam. It is this state of things which hinders the more general introduction of the Balanced Valve, because BEING BALANCED it takes LESS to lift it; and ignorant builders gravely object to its use as being "too sensitive." And it is thrown out; thereby removing the effect instead of enquiring into the cause.

In valves which cover the two steam ports and the mid or exhaust port at once, (Three Port Valves,) if there is no inside lap the exhaust of one port may pass over the mid port and enter the other port, and under unfavorable circumstances, produce back pressure, on the stroke just being completed. It was probably this fact which led many builders into the mistake of carrying out the same idea in Double Port Cylinders, when there is no neceesity for it. In fact it may safely be said, that there is no greater drawback to the average steam engine to-day, than this inside lap. It is this which makes some engines stop short of the dead centre and travel backward some distance without steam. It is this which causes the slide valve to jerk up off its seat as the piston nears the end of its stroke. It is this which causes some engines to make a great noise exhausting, because the Piston has to push the steam out of the Cylinder.

It is here the improvement is made when one builder undertakes to make some other builder's engines, do "double the work with half the fuel."

By proper attention to this alone, and having the Valve set properly by the Indicator, more fuel can be saved than by all other late improvements put together. It is evident then that Three Port Valves ought to be discarded, and Double Valves take their place on all engines, unless they are so small that it can't possibly be done; even this change on engines from 5 or 6 in. upward, would pay all parties for the steam wasted in the LONG ports each stroke, under ordinary circumstances, would run the engine two or three

hours out of every ten, easy, to say nothing of the chance it gives to exhaust earlier and cushion less.

EXAMPLE WITH LAP.

In this example the term Lap will mean the usual lap given to each end of the Valve, when on the middle of its travel, and the term inside lap, (used for want of a better,) will mean the distance A. (in Fig. 2) when the valve is in the position shown,

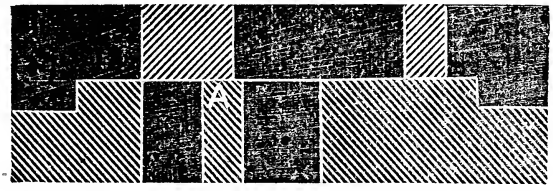

Fig. 2.

And to make the case plainer, we will assume a given size of engine and ports, and state in advance what disposition of steam is desired in the Cylinder.

Engine, 12 in. diameter of cylinder x 24 in. stroke, ports equal to one-tenth area of cylinder, equal to 12 in. by $1\frac{1}{8}$, to cut off steam at $\frac{2}{3}$ of the stroke, and to exhaust at 3 inches from end of stroke, and for a trial we will adopt $2\frac{1}{4}$ in. travel of valve, the cushion being a result to be determined. And to divest the "mark" of mystery, let us imagine it to be a mere wrist pin and a valve attached to it, and being draged along backward and forward by its movements.

The crank pin is on the dead centre line B. F., and the valve has to be moved ahead to take up the lap and give steam when in that position. This is done by simply making a new mark on the template. Removed from the thick line, in the direction of F., the amount of the lap required. If we had not known the amount of lap required we might try $\frac{3}{8}$ in., and if we found that would cut off too late, then $\frac{1}{2}$ in., &c., but it happens that $\frac{5}{8}$ plus $\frac{1}{32}$ is the required lap, and accordingly we make a mark on template

$\frac{5}{8}$ plus $\frac{1}{32}$ in. from thick line, measuring by the eye simply, as the upright lines stand $\frac{1}{8}$ in. apart. If the template be turned now it will be found that the steam port is opened $\frac{7}{16}$ in., and when the mark has arrived at the identical spot it started from, only on the under side of line B. F., it will be found that the crank pin stands at the $\frac{2}{3}$ line, and the piston has proceeded two-thirds of its stroke; but the exact distance in inches can be found by counting the curved lines from F. back to crank pin. Counting with pencil or pointer along stroke circle, each space representing in this case 1 in. It will be found there are eight of them and eight inches is the distance piston is from end of stroke.

Now the proper way to find the inside lap, is to move the mark round $\frac{1}{8}$ in. at a time, and at each $\frac{1}{8}$ in. stop and examine the position of the crank pin, to see if it is nearing the desired exhausting point. In this case $\frac{1}{8}$ in. would bring the mark to within $\frac{1}{32}$ of the fourth line from thick one, and the crank pin is some distance yet from 3d inch from end of stroke, (the exhausting point,) showing that $\frac{1}{8}$ in. is not enough inside lap. Another $\frac{1}{8}$ in. and the mark is within $\frac{1}{32}$ in. of third line, and still the crank pin is not at the desired place; we try another and examine, and still another, making $\frac{4}{8}$ in. in all, or $\frac{1}{2}$ in., and the crank pin wants a little yet; but by moving the mark $\frac{1}{32}$ in. more, making $\frac{1}{2}$ plus $\frac{1}{32}$ in. inside lap, we find by counting as before the crank pin has arrived at 3 in. from end of stroke. Now it is evident that further movement of the mark will result in opening the exhaust, and when it has moved to line B. F., the exhaust will be full open, and when it arrives at the same line again, on top side of line B. F., the exhaust will be closed. This we proceed to do, but we may as well observe as we go along, how much said port is open when piston is at end of stroke, by proceeding as before, counting one $\frac{1}{8}$ in. after another, we find six of them are passed before piston is at end of stroke, showing that the exhaust is $\frac{3}{4}$ in. open by the time crank pin is on dead

centre line; and further, we may as well see if exhaust port is going to be opened full or not. The mark was $\frac{1}{8}$ in. from thick line when exhaust port began to open, and will be full open when mark is on line B. F.; now the space intervening measures $1\frac{1}{4}$ in., whereas the port is only $1\frac{1}{8}$ in., consequently the valve travels, not only over the port, opening it full, but $\frac{1}{8}$ in. more; this is good as it wears the seat and valve uniform. Now by moving the mark round to the line corresponding with the opening of exhaust, viz: $\frac{1}{8}$ in. from thick line—we find the crank pin stands at $1\frac{3}{4}$ in. from end ot stroke, as the curved lines show $1\frac{3}{4}$ in. then is the cushion.

If it should be desired to have a little more cushion, we go back over the same ground and give more inside lap, but this amount, with slight lead, would run well at 300 or 400 ft. piston speed. Lead would have the effect of opening the exhaust sooner and reducing the cushion; but what was lost in cushion in this way, would be made up by the entering of the live steam before turning the centres, producing the same result, without the tendency to lift the valve off its seat. A note of results ought to be jotted down as they are found, and recorded in a book kept for the purpose when they are adopted. The results given by this valve would read as follows:

BACK AND FRONT.

	B.	F
Travel of Valve.	$2\frac{1}{4}$ inch.	$2\frac{1}{4}$ inch.
Lap,	$\frac{5}{8}$ plus $\frac{1}{32}$ inch.	$\frac{5}{8}$ plus $\frac{1}{32}$ inch.
Cut off,	8 inch.	10 inch.
Inside Lap,	$\frac{1}{2}$ plus $\frac{1}{32}$ inch.	$\frac{1}{2}$ plus $\frac{1}{32}$ inch.
Exhausts at	3 inch.	4 inch.
Expands,	5 inch.	6 inch.
Cushions,	$1\frac{3}{4}$ inch.	$1\frac{1}{2}$ inch.
Steam ort opens	$\frac{7}{16}$ inch.	$\frac{7}{16}$ inch.
Exhaust open at end of Stroke,	$\frac{3}{4}$ inch.	$\frac{3}{4}$ inch.
Exhaust Port opens	Full plus $\frac{1}{8}$ inch.	Full plus $\frac{1}{8}$ inch.

B. column denotes back end of cylinder and F. column the front end, which is found in the same way, only the Calculator is turned so that letters B. F. will read up side down. To make the Value cut off and exhaust equal, we

must give different amounts of lap on each end of the Valve. This would occasion the opening of one port sooner than the other, and also the difference wider. The result would be as follows:

	B.	F.
Travel of Valve,	$2\frac{1}{4}$ inch.	$2\frac{1}{4}$ inch.
Lap,	$\frac{5}{8}$ plus $\frac{1}{32}$ inch.	$\frac{5}{8}$ inch.
Cut off,	8 inch.	8 inch.
Inside Lap,	$\frac{1}{2}$ plus $\frac{1}{32}$ inch.	$\frac{1}{2}$ inch.
Exhausts at	3 inch.	3 inch.
Cushions at	$1\frac{3}{4}$ inch.	$1\frac{1}{4}$ inch.
Steam Port opens,	$\frac{7}{16}$ inch.	$\frac{1}{2}$ inch.
Expansion,	5 inch.	5 inch.
* Lead,	0 inch.	$\frac{1}{16}$ inch.

It will be seen that if a good thing is desired in one direction, it is at a sacrifice in another. But there are circumstances where this Lead, necessary for equal cut off, is very advantageous. In engines for instance where large reciprocating ports move vertically, it is sometimes neces sary to go even further than this and make a distorted valve purposly, to accomplish certain ends. The duty of the Calculator is done however when it shows the disposition of the steam under different conditions. It remains with the designer to choose which suits him best, and cut the valve to do his will.

If it is desired to see what effect lead obtained by moving the eccentric ahead will have, we proceed as before, but when the mark has moved forward the amount of lead required, move the template no further until we have made a new mark on template, coincident with line B. F., to represent new relation of crank pin to mark; and through the operation use this new crank pin in place of the old.

By moving template back to old position, i. e., till old crank pin is on line B. F., the new crank pin will show just how far the piston is from end of stroke. This is of some importance and ought to be jotted down with the

* The lead here mentioned is not the lead obtained by moving the eccentric ahead, but by cutting $\frac{1}{16}$ in. off one end of the valve.

others in case it be called in question. The record book will be found to be a good investment, if a reliable man is sent out to fit up the engines and sets the valve not "in the neighborhood of" but exactly as it is designed to be set. Paper templates ought to be made of valve and seat, and the (paper) valve moved along the (paper) seat, and seat trimmed off so that valve will move over every edge $\frac{1}{4}$ in., for this purpose the exhaust port ought to be $\frac{1}{4}$ in. wider than steam port. More can't hurt if valve is balanced.

A good plan to have seat and valve chipped and planed correct, is to prepare a stick with seats marked on one edge and valve on another, and these handed to the fitter to chip seats to. These sticks ought to be "laid off" very correctly; the lines drawn deep with a pen knife, and a small chamfer taken off one side of each line; and the space corresponding with ports varnished black, and the rest of the stick varnished yellow. It is not the design of these pages to discuss the size of steam ports, but I have frequently met young engineers discouraged by the great disparity of rules given by different writers. An examination of seven popular works, reveals the fact that the rules, by application, give results varying 45 per cent. For example, an engine 28 inches diameter of cylinder, by 48 inches stroke, making 60 revolutions, requires by one rule 41 square inches of steam port, while another calls for 76. The others more or less between these figures, the mean of all being 61. Aside from rules of this kind, the INDICATOR has done much towards establishing the proper size of ports. By its use $\frac{1}{10}$ the area of Cylinder's diameter is found to answer very well for the ordinary Slide Valve engines and piston speeds of to-day; and perhaps the explanation of the disparity refered to is to be found in the difference in the dates of publication; for not only has piston speed but steam pressure been on the increase for a number of years, the former from 250 to 600, the latter from 20 to 140. Although these high pressures and high speeds are not yet popular.

The next leap of economy in the steam engine will probably come in this direction; for with reciprocating ports well proportioned and counterbalanced, and slide valve properly balanced also, much will be gained by increased speed, other things being equal.

It is almost superfluous to add, that in the case of an old valve, we proceed in the same manner as in preceeding examples, only, in this case, the travel of valve, and lap and inside lap are known; and by making (paper) valve and seat, and moving them back and forth, equal the travel, we see whether the various edges pass OVER each other properly, and whether the dimensions of exhaust ports are encroached upon by movement of the valve in working. And by the Calculator we can see what effect more or less lap, or inside lap, will have, or more or less travel, in case its doings should be found to be unsatisfactory.

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